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LIFE HISTORY AND CONTROL OF THE ASIATIC GARDEN BEETLE

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INTRODUCTION

A few small brown beetles were found in a nursery near Rutherford, N. J., in 1921. Although they became more common each year thereafter, not until 1926 was the species identified as an insect from the Orient, *Autoserica castanea* Arrow. By this time this beetle, which soon became known in the United States as the "Asiatic garden beetle", had greatly increased in numbers and destructiveness in the territory surrounding New York City and gave promise of becoming a serious pest. This insect, though not destructive in Japan and China, its native homes, has in this country found conditions favorable for its multiplication and an abundance of the ornamental plants that it prefers as food. General interest has also been aroused because of the annoyance that the beetles have caused by flying about in brightly lighted places on warm summer evenings.

This circular presents information concerning the life history and habits of the insect, the injury it causes, and the control measures that have been found effective in combating it.

WHERE THE BEETLE OCCURS IN THE UNITED STATES

The Asiatic garden beetle occurs in largest numbers in suburbs of New York City and Philadelphia. In New York State it is generally distributed throughout Kings, Queens, and Nassau Counties, the western part of Suffolk County on Long Island, and in Bronx and Westchester Counties on the mainland. In New Jersey it is uniformly present and abundant in Essex, Hudson, and Union Counties as well as in parts of Bergen, Passaic, Middlesex, and Monmouth Counties. In the suburban area around Philadelphia the beetle is now found in numbers in parts of Chester, Delaware, Montgomery, and Philadelphia Counties.

There are other points, shown as dots on the map (fig. 1), where the insect has been found; in most cases, however, the area infested is small and the beetles are present in such small numbers that they are rarely noted by residents. It is probable that the beetle occurs elsewhere, but no effort has been made to determine its spread beyond the heavily infested area, and until beetles are present in sufficient numbers to become a nuisance or destructive to plants their presence might readily be overlooked and no report of their occurrence reach interested agencies.

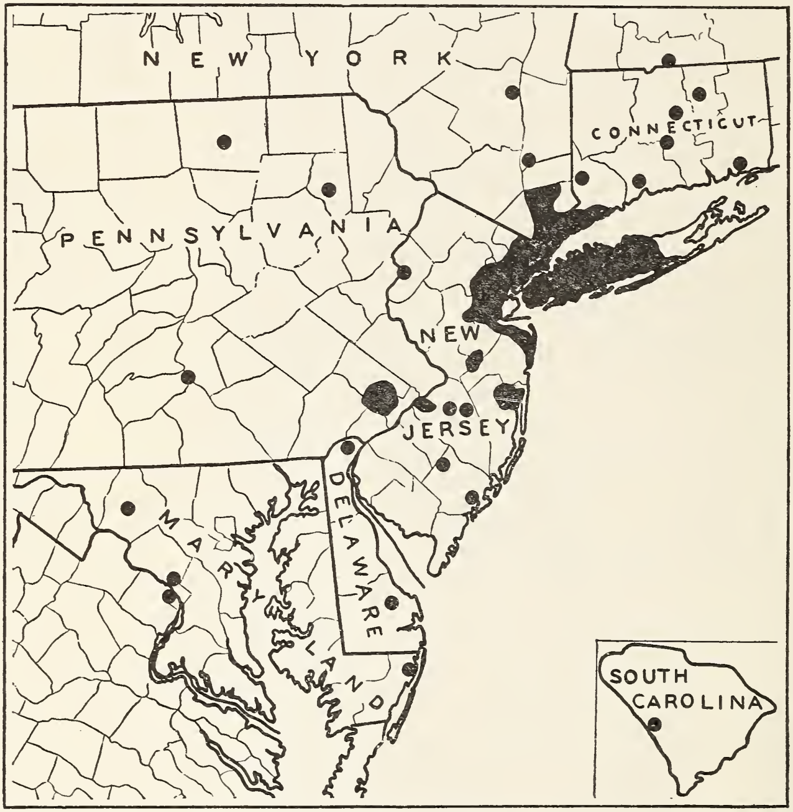

FIGURE 1.—Known distribution of the Asiatic garden beetle in the United States in 1935.

HOW ASIATIC GARDEN BEETLES SPREAD

When plants with soil about the roots or turf are moved from an infested area, it is always possible that larvae or adults, or both, may be carried to an uninfested location. Thus the movement of nursery stock or other ornamental plants may be instrumental in the spread of the insect.

As the beetles fly about on warm nights, there is a natural dispersion of the insect that, over a period of years, has brought about a gradual extension of the infested area. Beetles that fly into automobiles parked in lighted places may be transported for some distance. There is also the possibility of their being carried on flowers, garden produce, or on the clothing of persons. For beetles to be carried in this way, however, the movement of such persons or plants must take place at night, as with the return of daylight beetles always enter the ground.

HOW TO RECOGNIZE THE BEETLE IN ITS DIFFERENT STAGES OF DEVELOPMENT

The adult, or beetle, is from five-sixteenths to seven-sixteenths of an inch long, dull chestnut brown, with a slightly iridescent, velvety sheen, and superficially resembles a coffee bean (fig. 2). A few erect, irregularly arranged, backward-projecting hairs on top of the head are characteristic of this species.

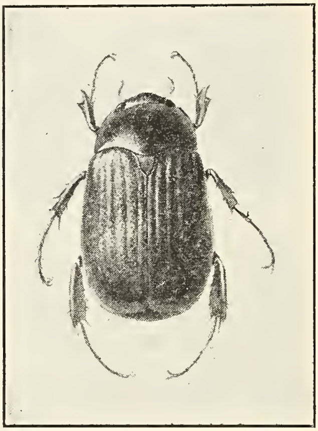

Figure 2.—The Asiatic garden beetle. Three and one-third times natural size.

The eggs are white, ovoid, and about one twenty-fifth of an inch in diameter. They are laid in clusters containing up to 19, loosely held together by a gelatinous material (fig. 3). After being in the soil a few days, the egg, which has increased in size, becomes nearly spherical in shape. When the time for hatching approaches, the egg clusters fall apart readily when disturbed.

The larva, or grub, when first hatched, is about one-eighteenth of an inch in length, but by the time it is full grown it measures about three-fourths of an inch. It has a distinct head and three pairs of legs, and it is normally curled up in the shape of a letter **C** (fig. 4). Larvae of the Asiatic garden beetle are similar in appearance to larvae of May beetles, commonly called "white grubs", but are usually smaller and lighter in color, and may be distinguished from them by characters shown in figure 5.[1] There is a single transverse row of spines on the underside of the last abdominal segment, which, with the smaller claw on the third leg, distinguishes the larva of this species from nearly all larvae that resemble it. The larva can also be distinguished by the light-colored, enlarged, bulbous palpi located on the side of the head near the jaws. These palpi are usually in motion.

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[1] For additional information on how to distinguish larvae of the Asiatic garden beetle from larvae that may be associated with it, consult the following publication: Sim, R. J. CHARACTERS USEFUL IN DISTINGUISHING LARVAE OF POPILLIA JAPONICA AND OTHER INTRODUCED SCARABAEIDAE FROM NATIVE SPECIES. U. S. Dept. Agr. Circ. 334, 20 pp., illus. 1934.

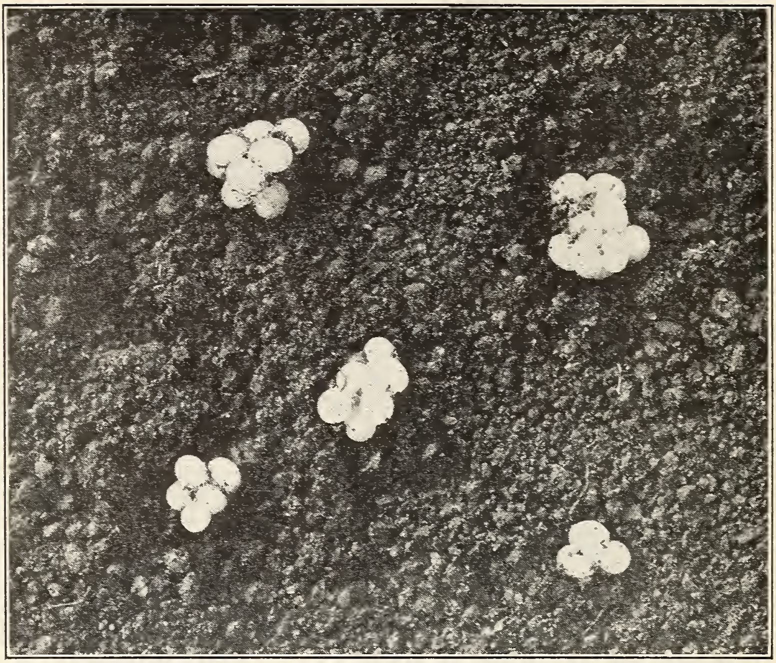

Figure 3.—Egg clusters of the Asiatic garden beetle. Three times natural size.

When mature the larva constructs an earthen cell about its body, stops feeding, voids the accumulated excrement, assumes a paler appearance, and in this inactive condition, in which it is known as a "prepupa", prepares for the change to the pupal stage.

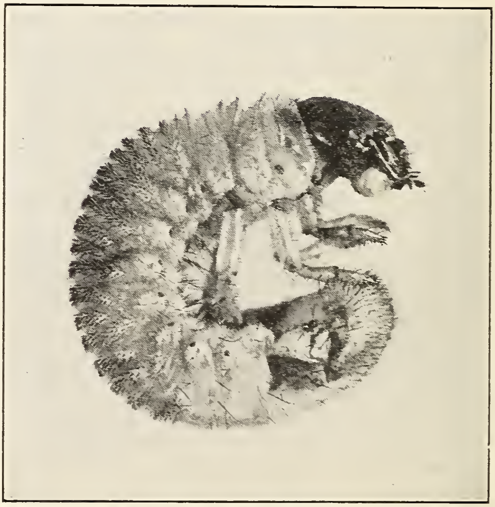

Figure 4.—Larva of the Asiatic garden beetle. Eight times natural size.

The pupa is approximately one-third of an inch in length and resembles somewhat the mature beetle in that the legs, antennae, and wings are distinguishable and closely folded about the body (fig. 6). When newly formed it is pure white, but it gradually becomes a tan color. It is formed within the old larval skin, which is soon pushed back over the end of the body, leaving the pupa free in the soil. The change to the adult occurs when the pupal skin splits down the back, allowing the beetle to emerge.

SEASONAL HISTORY

The first Asiatic garden beetles leave the ground during the last 10 days of June in the latitude of New York City, and may be found from then until the end of October. They are most abundant between July 15 and August 15. The average length of adult life is about 1 month, though beetles have been known to live more than 100 days.

The beetle is a night flier, and during the daylight hours remains concealed in the ground. While hiding in this way, beetles deposit the egg clusters that are the start of the new brood. Eggs are found in the ground at depths of from one-half inch to 4 inches, but usually in the top 2 inches of soil. In cages as many as 178 eggs have been deposited by a single beetle during its life, but the average is only about 60. The eggs hatch in about 10 days and may be found in the soil from the last of July till late in October.

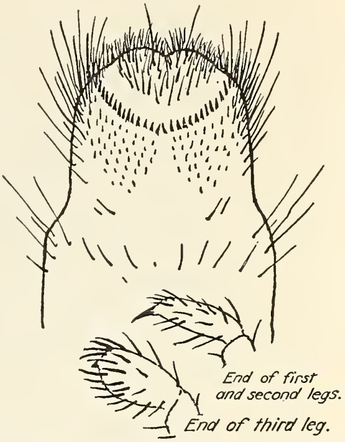

Figure 5.—Underside of last body segment of the Asiatic garden beetle showing distinguishing hairs, and tips of legs showing the claw character.

Newly hatched larvae feed on the roots of plants and on disintegrated vegetable matter. As they feed they grow, and during the growth period they pass through three stages, or instars. Normally 75 percent of the larvae enter the third instar before winter; the remainder, for the most part, reach the second instar, though occasionally even larvae in the first instar have been found late in the fall when further change would be prevented by low temperatures. However, as first-instar larvae have never been found in the spring, they are apparently unable to survive the winter. Feeding continues until cold weather sets in and, as full-grown larvae are more voracious feeders than smaller ones, some injury to the roots of plants may occur during the fall months.

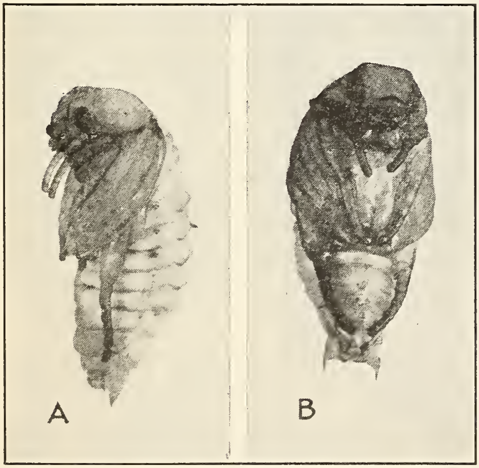

Figure 6.—Pupa of the Asiatic garden beetle: *A*, Lateral view; *B*, ventral view. Five times natural size.

About the middle of October larvae move downward in the soil to depths ranging from 6 to 12 inches, the majority at 9 to 11 inches. Here they become inactive and pass the winter in this dormant condition. About the middle of April they again become active, move upward to the top 5 inches of soil, and resume feeding on the roots of plants. Larvae that have passed the winter in the second instar now continue to grow and change to third-instar larvae. Injury to the roots of plants may also occur during this feeding period.

The greater part of the life of the Asiatic garden beetle is spent in the larval stage, which continues from the time eggs hatch in August through the fall and winter and until the latter part of the following June. The mature larva then constructs an earthen cell from 1½ to 4 inches below the surface, in which, after spending about 4 days in the comparatively inactive prepupal state, it again sheds its skin and becomes a pupa. Pupae are present in the soil normally during the last half of June and first half of July, the time spent in this stage ranging from 8 to 15 days, with an average of 10 days. At the end of this period the pupal skin splits and the newly formed beetle appears, but it remains within the pupal cell until its body becomes hardened and its color has changed from a white to chestnut brown. It then burrows upward and emerges from the soil as the fully formed beetle.

The seasonal cycle of the beetle, shown diagrammatically in figure 7, requires, therefore, approximately 1 year.

FEEDING HABITS AND FOOD PLANTS

As previously noted, the Asiatic garden beetle is a night-flying insect. At dusk it leaves the ground where it has been hiding during the daylight hours and begins to feed. On cool evenings, when the air temperature is below 70° F., beetles do not fly about, but feed lightly, largely on plants near their daytime hiding places. A few beetles will come out and feed in this way when the temperature is as low as 60°, but they emerge in larger numbers when the temperature ranges between 65° and 70°.

When the temperature is 70° F. or above, however, beetles leave the ground and fly about in all directions. They invade gardens where their favored food plants are growing and feed so intensively that the foliage is sometimes seriously injured in a single night. Even where beetles are not abundant, the continued feeding night after night will often result in damage. When home owners do not see the culprits at work during an evening, they are rightly puzzled as to the cause of the damage, for when the plants are examined the following morning the beetles have again returned to the soil. As the temperature gradually falls during the evening, beetles stop flying and feeding, and reenter the soil.

The beetle begins to feed at the margin of the leaf and cuts out a portion of the tissue (fig. 8) with its jaws. In cases of moderate feeding the foliage becomes ragged (fig. 9), but when feeding is heavy all the leaf tissue may be eaten away and only the midribs remain. On flowers the edges of the petals are attacked first, and as feeding continues flowers take on the ragged appearance shown in figure 10. Beetles often eat into the sides of rosebuds, thus preventing the formation of perfect flowers.

The degree of the injury depends largely on the size of the plantings. For example, if only a few highly preferred chrysanthemums are growing in a garden, they may be completely stripped, while a large planting in the same place would show only slight injury, because the insects tend to feed equally on all plants of a given kind.

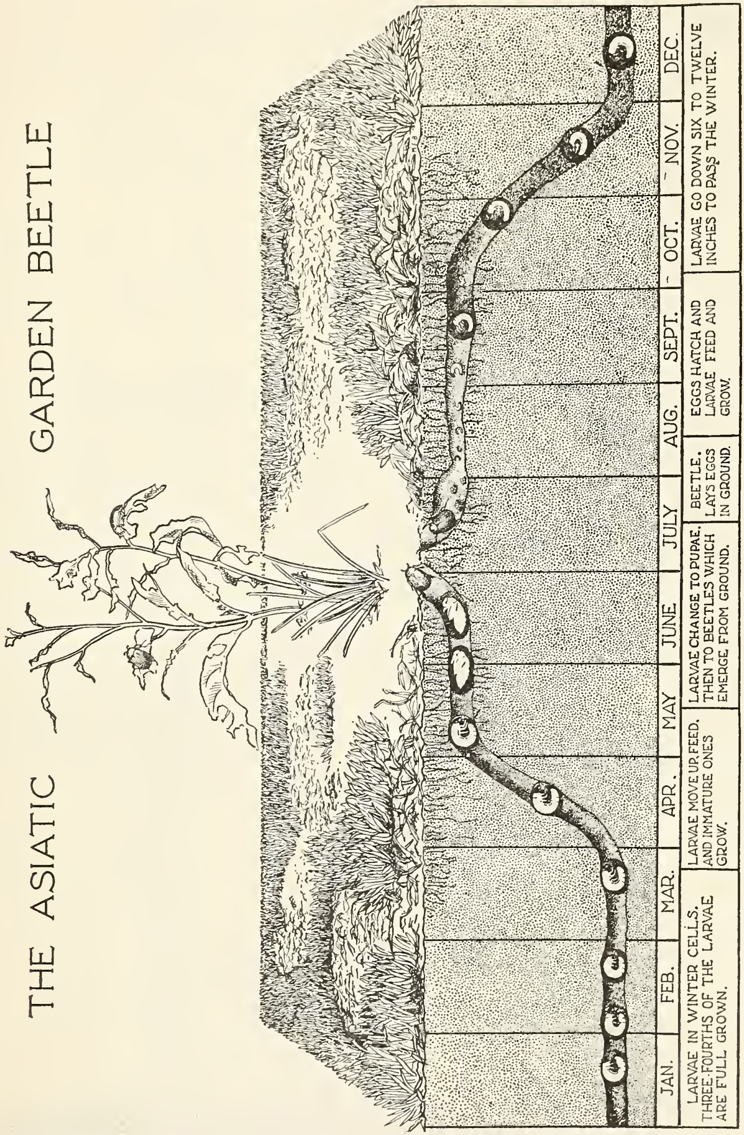
THE ASIATIC GARDEN BEETLE
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
LARVAE IN WINTER CELLS. THREE-FOURTHS OF THE LARVAE ARE FULL GROWN.
LARVAE MOVE UP, FEED, AND IMMATURE ONES GROW.
LARVAE CHANGE TO PUPAE, THEN TO BEETLES WHICH EMERGE FROM GROUND.
BEETLE. LAYS EGGS IN GROUND.
EGGS HATCH AND LARVAE FEED AND GROW.
LARVAE GO DOWN SIX TO TWELVE INCHES TO PASS THE WINTER.

FIGURE 7.—Diagrammatic representation of the seasonal life cycle of the Asiatic garden beetle.

The beetle has been a pest in ornamental gardens since it first became abundant in this country. Many of its preferred food plants,

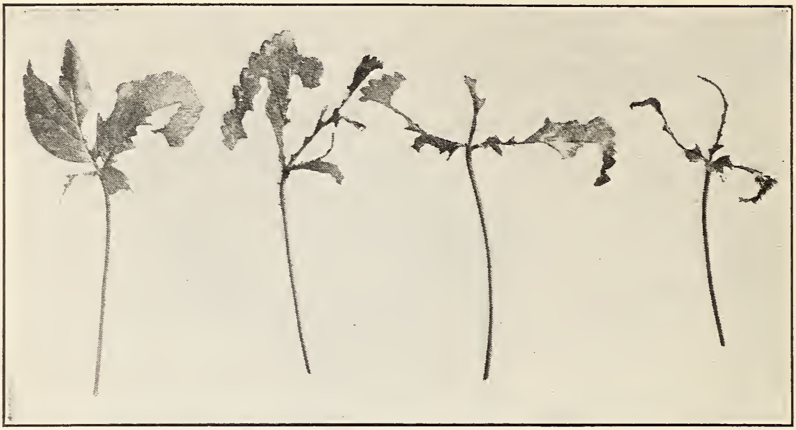

FIGURE 8.—Strawberry leaves showing typical feeding by the Asiatic garden beetle.

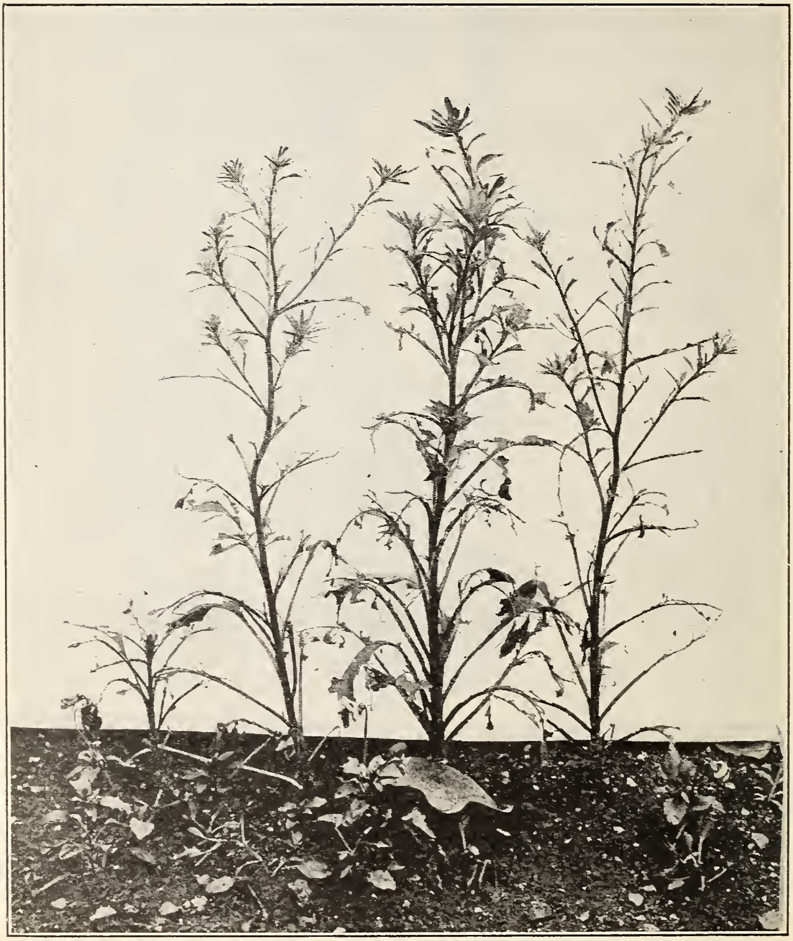

FIGURE 9.—Characteristic injury to asters caused by the Asiatic garden beetle.

such as asters, chrysanthemums, dahlias, strawflowers, and sunflowers, are commonly grown in flower gardens, and injury to these plants has occurred each year. In some cases 50 to 100 percent of the blossoms have been ruined.

During the last few years the beetle has occasionally been injurious in vegetable gardens where beets, carrots, eggplants, parsnips, peppers, and turnips have been grown. In the last 2 or 3 years it has been especially destructive in the subsistence gardens of the unemployed on Long Island, not only to the plants mentioned above, but also occasionally to broccoli, cabbage, spinach, and Swiss chard. In some of the small, late plantings so heavy was the feeding on the tops of carrots that only the whiplike midribs of the leaves remained. Up to the present time, however, injury in other vegetable gardens has been observed only rarely, where for some reason there has been an unusually high beetle concentration.

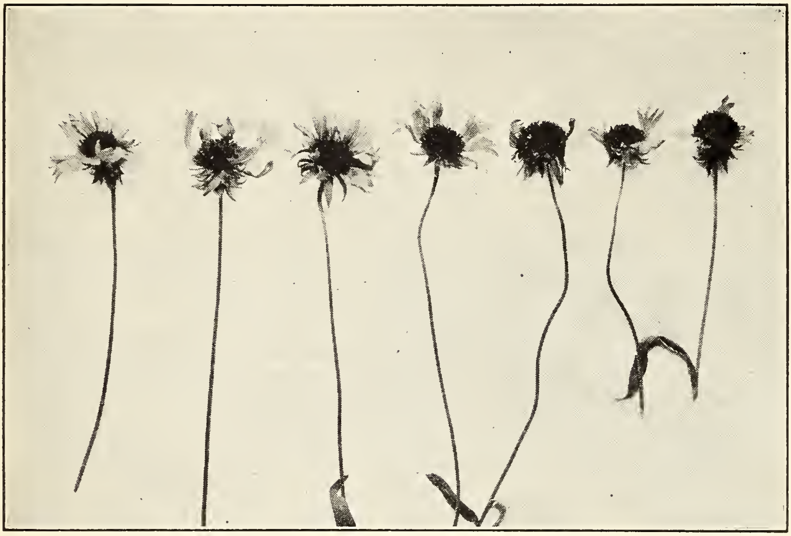

FIGURE 10.—Characteristic injury to flowers of gaillardia caused by the Asiatic garden beetle.

The Asiatic garden beetle has been observed to feed on approximately 80 kinds of plants, but it does not relish all of these to the same extent. The preferred plants, marked with an asterisk (*) in the following list, are always subject to attack, while the others are eaten only when beetles are abundant or preferred plants are absent. In rare cases feeding has been noted on a few plants that are not included in the list. Certain plants designated as preferred food plants in previous lists are not so considered here, as recent observations do not justify giving them this status. Unless otherwise noted, only the foliage of the plants is eaten.

FOOD PLANTS OF THE ASIATIC GARDEN BEETLE

- Ornamental shrubs and trees:
  - *Ailanthus.
  - Boxelder.
  - Butterflybush.
  - Catalpa.
  - *Devils-walkingstick.
  - Forsythia.
  - Horsechestnut.
  - Hydrangea.
  - Japanese barberry.
  - Locust.
  - Magnolia.
  - Mockorange.
  - Oriental cherry.
  - Privet.
  - *Rose (foliage and flowers).
  - Shrub-althea.
  - Silver maple.
  - *Sumac.
  - *Viburnum.
  - Willow.
- Bush and tree fruits:
  - Blackberry.
  - Blueberry.
  - Cherry.
  - Currant.
  - Mulberry.
  - Plum.
  - Peach.
  - Strawberry.
- Forage, truck, and vegetable-garden plants:
  - Bean.
  - Beet.
  - Broccoli.
  - Cabbage.
  - *Carrot.
  - Eggplant.
  - Kohlrabi.
  - Parsnip.
  - Radish.
  - *Redpepper.
  - Rhubarb.
  - Spinach.
  - Sweetpotato.
- Forage, truck, and vegetable-garden plants—Continued.
  - Swiss chard.
  - *Turnip.
  - White clover.
- Flowering garden plants:
  - Ageratum.
  - Aquilegia.
  - *Aster (foliage and flowers).
  - Begonia.
  - Canna.
  - Castor-bean.
  - *Chrysanthemum.
  - *Dahlia (foliage and flowers).
  - Foxglove.
  - *Flame-ray gerbera (foliage and flowers).
  - Four-o'clock.
  - Gaillardia.
  - Geranium.
  - Gladiolus (flowers only).
  - Goldenglow (foliage and flowers).
  - *Hemp.
  - Lantern groundcherry.
  - Larkspur (foliage and flowers).
  - Morning-glory.
  - Orchid (flowers and foliage).
  - Phlox (foliage and flowers).
  - Scarlet sage.
  - Snapdragon.
  - *Sunflower (foliage and flowers).
  - *Strawflower (foliage and flowers).
  - Zinnia (foliage and flowers).
- Weeds:
  - Beggarticks.
  - Burdock.
  - Cocklebur.
  - *Common ragweed.
  - Daisy fleabane.
  - Goldenrod.
  - *Great ragweed.
  - Lambsquarters.
  - Pigweed.
  - Plantain.
  - Smartweed.
  - Velvetleaf mallow.

FLIGHT OF THE BEETLE ABOUT LIGHTS

As the beetles fly about on warm nights they are attracted to electric lights. In such situations they not only fly actively but collect on any lighted objects nearby. The more powerful the lights the greater the number of beetles that are drawn to them, and the more annoying they become by flying against and alighting on persons. They have been so abundant about baseball parks, dog race tracks, golf driving courses, road stands, open-air restaurants, swimming pools, and similar brightly lighted establishments in the vicinity of New York City and Philadelphia that the proprietors have repeatedly complained that customers are driven away. In heavily infested localities it is not unusual to find hundreds of beetles on the walls and screen doors of drug stores and restaurants that are open during the evening and have highly illuminated signs. Beetles have been especially abundant where blue mercury-vapor lights are used.

At golf driving courses lighted by batteries of powerful flood lights thousands of beetles sometimes collect on the poles beneath the lights and on objects in the lighted area. They have been so abundant on automobiles parked beneath the flood lights that a handful of beetles could be collected in one sweep of the hand over the top of a car. Several cases have been reported of beetles entering the ears of persons in such places and impairing the hearing by injury to the ear drums. Beetles are drawn especially to persons wearing white or light-colored clothing.

It is not definitely known how far the beetles fly, but apparently they can travel considerable distances, since they are known to fly from 200 to 500 yards in the direction of lights. At times they travel at great heights. On one occasion they were collected on the roof of a 30-story building in New York City, but in this case they were probably aided in their flight by wind currents. This habit of flying to lights aids in determining whether the beetles are present in a locality, for if they are present they will be found in the vicinity of lights on hot evenings.

PLACES CHOSEN FOR EGG LAYING AND THEIR INFLUENCE ON LARVAL ABUNDANCE

The Asiatic garden beetle does not deposit its eggs in equal numbers in all places in the soil. The relative attractiveness of different locations for oviposition is important, since it governs the abundance of larvae.

Many eggs are laid in well-kept lawns, where larvae have sometimes been numerous enough to injure the turf. In lawns, as in other situations, larvae tend to be more abundant near favored food plants. If there is a rose garden or a bed of chrysanthemums along one side of a lawn, larvae will be especially abundant in that portion of the lawn.

Eggs are normally laid in greatest numbers, however, in overgrown weedy land in which such plants as bunch grass, daisy fleabane, goldenrod, plantain, orange hawkweed, ragweed, wild aster, and wild carrot are growing. Since of these plants only goldenrod and ragweed are fed upon, there must be some other reason for oviposition in this type of land. Since larvae have usually been from 5 to 10 times as abundant about orange hawkweed as in similar situations where this plant does not occur, it evidently presents a highly desirable place for oviposition. Orange hawkweed is a low-growing plant that shades the ground and keeps the soil cool and moist so that it is highly acceptable to the beetle as a place to hide during the day and deposit its eggs. Larvae have also been numerous about corn, peanut, sorrel, and tomato—all plants that shade the ground and are not fed on by the beetle.

The subsistence gardens that were started on Long Island in the summer of 1933 were, for the most part, located on tracts of land that had not been in cultivation for several years and were consequently largely overgrown with weeds. In several cases it was found that, after the ground had been prepared and planted to vegetables, many of the plants were fed upon so heavily by the larvae of this insect that nearly all the small seedlings were destroyed.[2] Larvae were abundant in these gardens because the beetles had been attracted to these weedy uncultivated areas to deposit their eggs.

This type of overgrown land is common in many suburban areas where the beetle occurs, and provides favorable breeding places which will doubtless continue to turn out beetles in large numbers each year as long as these places remain in this unkept condition. There is thus small prospect that it will be possible greatly to reduce the numbers of the beetles that are present in these places and that are attracted to lights on warm nights. It would seem, therefore, that the Asiatic garden beetle, in addition to injuring plants, is destined to continue to be a nuisance to residents of the infested areas.

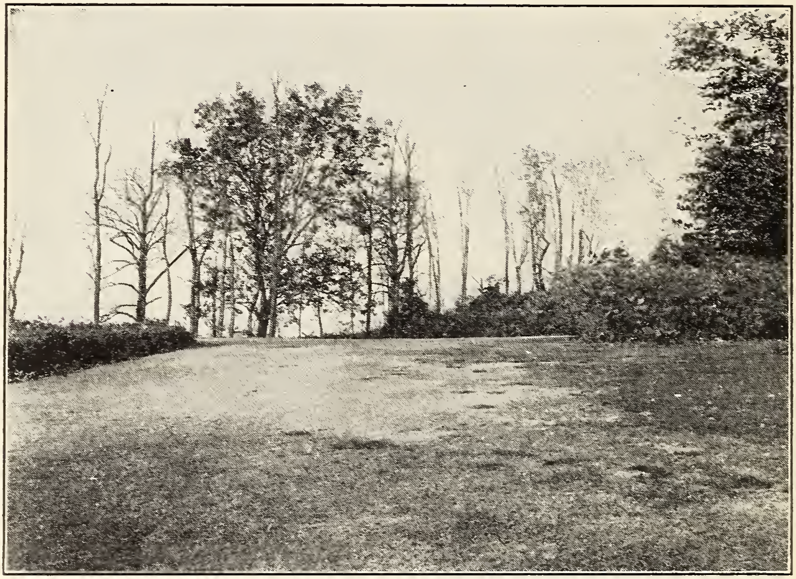

FIGURE 11.—A lawn injured by the feeding of larvae of the Asiatic garden beetle on the roots of the grass.

FEEDING HABITS OF LARVAE AND THE INJURY THEY CAUSE

The feeding habits of larvae of the Asiatic garden beetle, though less spectacular than those of the adult, are often of considerable importance. As stated above, larvae occur in large numbers in grass sod (fig. 11) and in even greater numbers in land overgrown with weeds; smaller numbers may be found in cultivated fields and gardens. As many as 150 larvae to the square foot have been found in sod in lawns, and 20 larvae to the square foot are enough to ruin the turf. The feeding on the roots makes the sod turn brown, but as lawns may acquire this appearance from other causes it is best to examine the soil beneath turf to determine whether larvae are present. This may be done by removing a section of sod and working over the soil beneath to expose the larvae. Severely injured turf often has a spongy feeling when stepped on.

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[2] HALLOCK, H. C. THE ASIATIC GARDEN BEETLE AS A PEST IN VEGETABLE GARDENS. Jour. Econ. Ent. 27: 476–481, illus. 1934.

Larvae of the Asiatic garden beetle are, however, normally less destructive to turf than are larvae of the Japanese beetle and the oriental beetle, which are sometimes associated with it. The larvae of the last-named insects feed just beneath the surface of the ground and eat off the roots of the grass, whereas larvae of the Asiatic garden beetle tend to feed deeper and eat the lower rootlets, which causes less damage.

The presence of larvae of the Asiatic garden beetle in weedy, overgrown land attracts little notice until the land is broken up and brought into cultivation. As already noted, most of the injury in vegetable gardens has resulted from this procedure, for the larval population in these newly planted gardens has sometimes averaged 50 to the square foot, and 5 to 10 larvae to the square foot are enough to cause noticeable injury in gardens, especially when humus is scarce, soil moisture is low, and plants are small at the time larvae are feeding in May and June. Larvae are usually more abundant in overgrown land than in gardens that have been cultivated for 2 or more years. In one case larvae averaged 49 to the square foot among the weeds near a garden and only 7 to the square foot about the plants in the garden.

Larvae feed in the top 5 inches of soil, the majority 2 to 3 inches beneath the surface. Owing to the looser texture of the soil, they are usually deeper in cultivated fields and gardens than in turf. In feeding, they cut off portions of the roots of their food plants with their biting jaws, and then ingest this food material together with surrounding soil particles. Larvae develop best in moist loamy soil, but they have been found in a wide variety of soil types ranging from loam to gravel. In dry summers larvae have been especially abundant in low, moist places, where beetles find easier access to the soil to hide and deposit eggs.

Larvae are always moving about through the soil. They move upward in the spring and downward in the fall, reacting to changes in the soil temperature, and they also move about to find favorable food and feeding conditions. They have been found to move horizontally as far as 3 feet through turf and still greater distances in bare soil and in gardens where their food supply is not uniformly abundant. They are often found concentrated about living plants on the edge of a lawn or garden and are scarce or lacking in areas where plants have been killed by their feeding and are no longer attractive.

Most plants are susceptible to larval attack, though those with succulent root systems are preferred. In vegetable gardens where seedlings of nearly all the common vegetables have been injured to some extent (fig. 12), potatoes have usually escaped injury. Injury to the roots of strawberry has been common, and in ornamental gardens such plants as aquilegia, begonia, chrysanthemum, and sedum have at times been attacked.

NATURAL FACTORS INFLUENCING BEETLE BEHAVIOR AND ABUNDANCE

CLIMATIC CONDITIONS

The weather plays an important part in the development and survival of the Asiatic garden beetle. In summers with deficient rainfall the mortality of eggs and small larvae may be so great that beetles are less abundant the following year. This was the case in 1929 in Nassau County, N. Y., when the total rainfall for June, July, and August was only 2.57 inches, as compared with a normal rainfall of more than 12 inches.

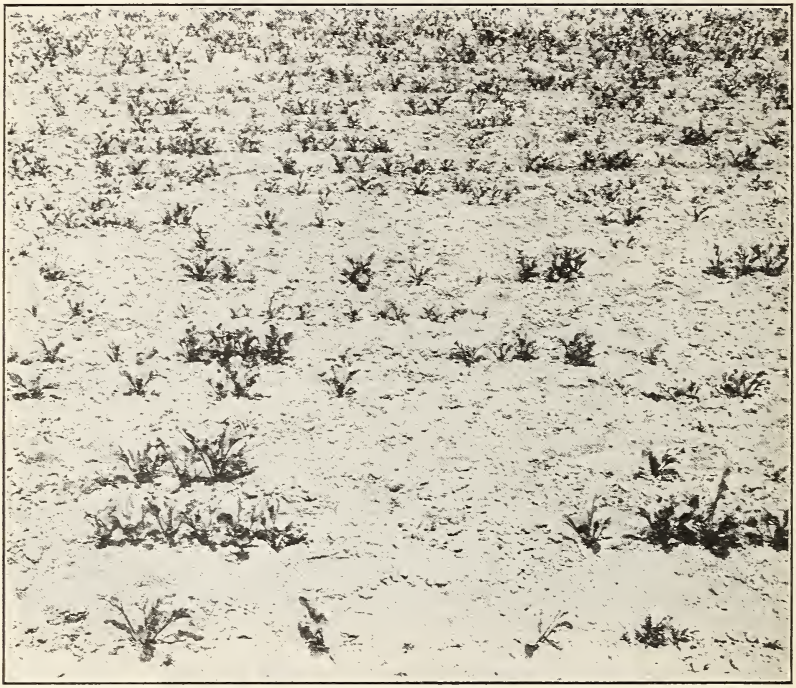

FIGURE 12.—A beet field, showing gaps in the rows where seedlings have been killed by the feeding of larvae of the Asiatic garden beetle on the roots of the plants.

As already noted, evening temperatures govern to a large extent the feeding and flight of beetles. If the insect spreads north where evenings are cooler, it is probable that there will be fewer nights with heavy flight, and because of lower soil temperatures the growth of larvae should be slower and adults emerge later in the summer. If the insect moves farther south and encounters warmer conditions, it is probable that beetles will be in flight on more evenings, will feed more intensively, and that their yearly spread will be greater. If this insect spreads to the Southern States, it is probable also that there will be a partial, if not complete, second brood each year. The reason for this belief is that under laboratory rearing conditions the insect has gone through one brood after another without requiring a diapause or lengthening out of the time of development in any of the stages. In a constant-temperature chamber run at 81° F., three broods of beetles were reared between September and the end of the following June.

In the present range of the insect there is no evidence that overwintering larvae have suffered from low winter temperatures. Though the last two winters have been unusually cold, the abundance of snow during the cold periods has prevented the soil temperatures at the depths where larvae occur from falling low enough to kill them.

NATURAL ENEMIES

Most injurious insects have enemies in the form of birds and other insects that tend to destroy them. The Asiatic garden beetle is surprisingly free from such enemies. As it is a night-flying species, the beetle is not in this country preyed on extensively by birds, though the European starling has been observed to dig into the daytime hiding places and feed on the beetles. In both the larval and the adult stages this insect appears to be free from attack by native insect parasites or disease organisms of any kind.

There are certain parasitic wasps of the genus *Tiphia* that prey on the larvae in China and Japan, and an effort is being made to introduce and establish these beneficial forms at points where beetles are abundant in this country. One parasitic wasp, *T. asericae* Allen and Jaynes, has been liberated in the Philadelphia area, and recoveries have been made showing that this parasite is now established there. An attempt has also been made to establish this species on Long Island and in northern New Jersey, but it is still uncertain whether it has become established at these points. Another species of parasitic wasp has recently been imported from Japan and has been liberated in the infested area, but it is still too early to determine whether it has become established.

BEETLES SOMETIMES MISTAKEN FOR THE ASIATIC GARDEN BEETLE

In the area centering about New York City, in which the Asiatic garden beetle occurs, there are now three other introduced scarabaeid beetles that may be confused with it.

The most important of these is the Japanese beetle (*Popillia japonica* Newman), now found everywhere around Philadelphia and becoming more abundant each year in the vicinity of New York City. This beetle is bright green, with brownish wing covers, is larger, and is a day flier. It may thus be readily distinguished from the night-flying brown Asiatic garden beetle.

A second introduced species, the oriental beetle (*Anomala orientalis* Waterhouse), occurs on Long Island and in Westchester County in New York State, in northeastern New Jersey, and in southwestern Connecticut. This beetle is about three-eighths of an inch long and varies from straw color to black, but is typically straw color with dark markings on the thorax and wing covers. This beetle is active during the warm part of the day, hovering close to the ground over turf. It is a pest only in the larval stage, when it feeds on the roots of grass.

A third introduced species, the imported *Serica* (*S. similis* Lewis), is found locally in Queens and Nassau Counties, N. Y., but has not yet become abundant or destructive. The adult of this species resembles the Asiatic garden beetle, but is more slender and yellowish brown. Like the Asiatic garden beetle, adults of the imported *Serica* fly to lights, but they are found on the wing earlier in the summer, mostly late in May and in June.

There are also certain small, native brown leaf chafers of the family Scarabaeidae, to which all the forms mentioned above belong, that superficially resemble and may occasionally be found associated with the Asiatic garden beetle, but these native forms seldom occur in such large numbers as the Asiatic garden beetle.

CONTROL OF THE ADULT

ARSENICAL SPRAYS

In most situations plants can be protected from the attack of the Asiatic garden beetle by spraying them with acid lead arsenate. Beetles feed readily on the poisoned foliage and are killed. However, since most of these beetles enter the soil before daybreak and die there concealed from view, no evidence of their death is to be found about the plants. This has led some persons to question the efficacy of sprays, but cage studies and field observations have shown that beetles are killed by this feeding.

In periods of continued warm weather when beetles are unusually numerous and actively flying, new swarms of beetles sometimes fly to favored food plants night after night. If these plants are sprayed with lead arsenate, the beetles will be killed, but the plants may eventually be seriously injured as a result of the continued reinfestation. Only a few such cases have been observed, however, and sprays are adequate in most situations.

Ornamental shrubs and flowers that need protection should be sprayed not later than July 10 in a normal season with 6 pounds of powdered acid lead arsenate and 4 pounds of wheat flour to 100 gallons of water. When only small quantities of spray are needed, the proportion should be 5 ounces of powdered acid lead arsenate and 3½ ounces of flour to 5 gallons of water. Additional applications should be made as needed to keep the plants well covered as long as beetles continue to feed.

Since fruit trees, small fruits, and most garden vegetables are not highly preferred food plants, they seldom require protective sprays. When arsenical sprays are applied to such plants, however, they should be used in accordance with recommendations made by State experiment stations or extension services for local conditions, and care taken to avoid injury to the tree and excessive residues at harvest time.

LIGHT TRAPS

Advantage has been taken of the attraction of the beetle to lights to catch the insect by the use of light traps. Studies along this line have been carried on for 8 years, and many kinds of lights and several styles of traps have been tested. At present two traps, similar in design but differing in size and light source, are in use. These traps, designated, respectively, as "the small trap" and "the large trap", will be discussed separately, as the conditions under which they are effective differ somewhat.

The small trap (fig. 13) is the one best adapted for general use in home yards and gardens where there is no competition with other lights. It consists of a funnel and above it a baffle with four wings, in the cut-out center of which is a 100-watt daylight lamp in a regular screw socket. To the lower end of the funnel a screw cap is soldered to which a fruit jar is attached to catch the beetles. The baffle and the inside of the funnel are painted white, and the outside

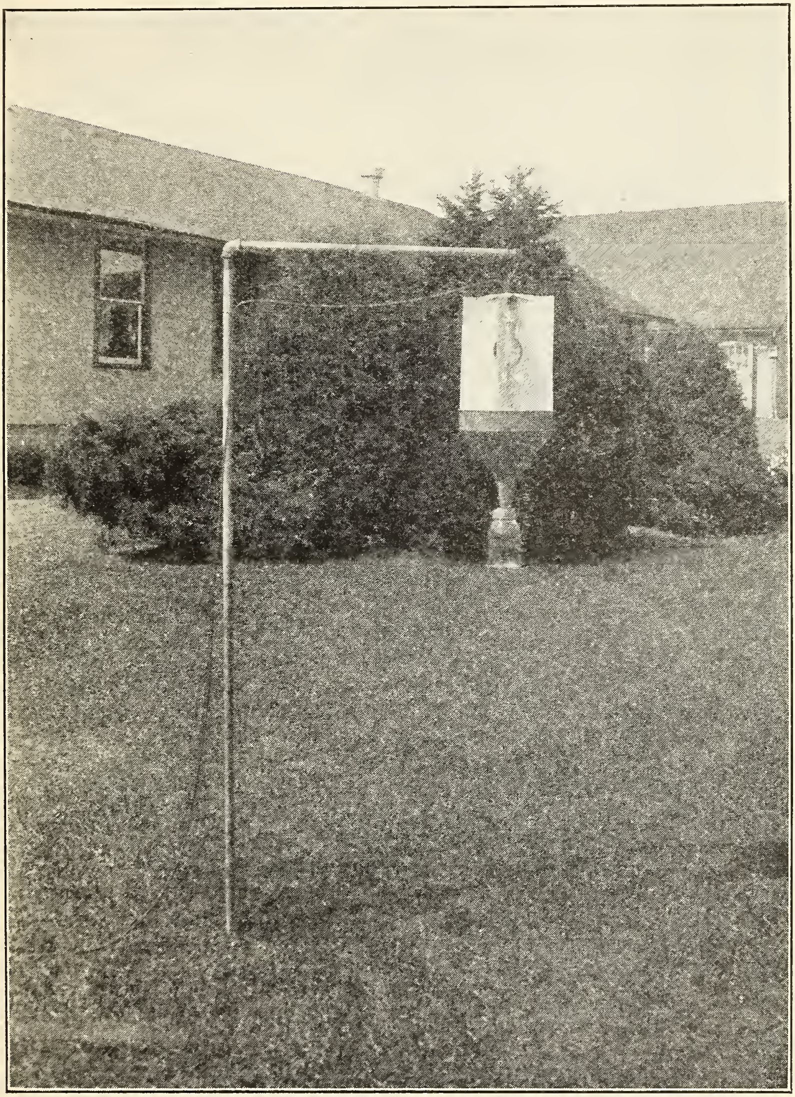

FIGURE 13.—A light trap of the small type used to catch the Asiatic garden beetle.

of the funnel is painted green. When in use the trap is suspended from a metal standard, which has been thrust into the ground. The light may be connected directly to any 110-volt alternating-current home-lighting circuit. This trap is cheap to build[3] and operate and, in places with heavy beetle populations and no competing lights, has caught as many as 2,000 beetles per hour.

The large trap has the same general structure as the small trap, but the funnel and baffle are larger and the cut-out area in the center of the baffle is made large enough to admit a G–5 mercury-vapor lamp. This lamp emits a bluish light that is more attractive to the beetles than that of any other of the 11 lamps tested. As many as 4,700 beetles per hour have been taken in this trap. The large trap is more expensive, since the G–5 bulb costs more than an ordinary daylight bulb and requires a special reactor or transformer when used on the usual alternating-current lighting circuit, and also a special socket. This trap has proved effective in such brightly lighted places as golf driving courses, where the small trap is of little value.

The question has arisen whether it is possible materially to reduce the numbers of beetles in brightly lighted places by the use of light traps. To obtain information on this point, traps of the large type were operated on a golf driving course in northern New Jersey for a few days in 1934 and throughout the 1935 beetle season. In 1935 more than 300,000 beetles, approximately 100 quarts, were caught. Although it is still too early to determine whether a catch of this size will appreciably reduce the beetle population the following year, it is possible that a trapping program such as this, when carried out for several years in an area that is not too heavily infested, may have some value.

There is still some question as to the efficiency of traps as a control measure. On Long Island, where the beetle has been abundant for several years, traps such as were then in use have been built and operated by residents, and there is a general feeling that they have been of value in reducing beetle feeding. With our present knowledge of the beetle population in such situations, however, it is uncertain just how much of the reported reduction in numbers should be attributed to traps. Without doubt the traps described above will catch many beetles, but they should be used in conjunction with sprays and other control measures and not as a substitute for such practices.

CONTROL OF THE LARVA

When larvae are present in numbers sufficient to injure turf, the sod in the affected lawn or golf course may be protected by treating the area with acid lead arsenate according to the procedures developed for the control of the Japanese beetle. The larvae can be controlled on established lawns by applying powdered acid lead arsenate to the surface at the rate of 10 pounds to 1,000 square feet of ground surface.

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[3] For the benefit of those persons who might be interested in building such a trap, the following specifications are given: The funnel is 12 inches in diameter at the top and about 1 inch at the bottom. Funnels of the type shown may be purchased at hardware stores, but funnels that serve equally well may be made by a tinsmith. The baffle wings are of tin, 14 inches high, 6 inches wide, and extend about 2 inches down into the funnel. The cut-out area in the baffle is 4½ inches in diameter at the widest point, just large enough to permit the placing of a 100-watt daylight bulb in the screw socket that is attached to the strengthening support at the top of the baffle.

It is largely a matter of choice whether the chemical is applied in a dry state, mixed with a suitable carrier, or in water. Where it is more convenient to apply the lead arsenate in a dry form, it is recommended that it be mixed thoroughly with a bushel of sifted soil or other carrier to facilitate proper distribution.

Where it is more convenient to apply the chemical in liquid form, a power sprayer having a pressure of 250 to 300 pounds and equipped with a Worthley nozzle and a baffle should be used. A mixture containing 1 pound of lead arsenate to 2 gallons of water is recommended, applied at the rate of 10 pounds of the lead arsenate to 1,000 square feet of ground surface. The use of a relatively insoluble material such as lead arsenate with water, especially in such high concentration, necessitates sufficient constant agitation to keep the material in suspension. After the spray has been applied and before it has had time to dry, the lawn should be watered sufficiently to wash the material off the grass and into the ground.[4]

Once the larvae are present about ornamental and vegetable-garden plants, there is no practical method of preventing their feeding on the roots. Since larval injury in gardens has usually occurred where overgrown weedy ground has been brought into cultivation for the first time, it is suggested that potatoes be planted the year this overgrown type of land is brought into cultivation. Since larvae do not injure and the beetles do not feed on potato, it is probable that oviposition will not be heavy enough to cause a high larval concentration the following year.

There have been numerous reports of larval injury in old strawberry beds. Strawberry beds are apparently favorable for oviposition because of the shading of the ground by the plants. Beds that are mulched with hay or straw during the egg-laying periods have fewer larvae than those that are not mulched.

SUMMARY

The Asiatic garden beetle, an insect from the Orient first found in the United States in 1921, has become a pest of ornamental garden plants in the suburban areas around New York City and Philadelphia. It is also a nuisance about electric lights on warm summer evenings.

Beetles may be carried into uninfested places by the shipment of plants with soil about the roots or by the movement of flowers and garden produce. They may also be carried in automobiles and on the clothing of persons.

Beetles begin to emerge during the last 10 days of June and may be found until the end of October, though they are most abundant between July 15 and August 15. The insect flies on warm evenings and during the day is concealed in the soil. One female lays about 60 eggs in the soil during the summer. These eggs hatch in approximately 10 days, and the larvae feed on the roots of plants. Normally 75 percent of the larvae are full grown by fall and all pass the winter in a dormant condition at depths of 6 to 12 inches. The following April they move up in the soil and again begin to feed and continue to do so until June when, after spending about 4 days as a prepupa and 10 days as a pupa, they transform into beetles. The entire life cycle requires 1 year.

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[4] The procedure for treating turf is fully described in the following publication: FLEMING, W. E. PREVENTING INJURY FROM JAPANESE AND ASIATIC BEETLE LARVAE TO TURF IN PARKS AND OTHER LARGE AREAS. U. S. Dept. Agr. Circ. 403, 12 pp., illus. 1936.

Feeding is heaviest on warm nights, and if the temperature is 70° F. or above, the beetles will fly about and concentrate their attack on preferred food plants, often seriously injuring them. The beetle is primarily a pest of such ornamental plants as asters, chrysanthemums, dahlias, strawflowers, and sunflowers, but such vegetable-garden plants as beets, carrots, eggplants, parsnips, peppers, and turnips are sometimes attacked. About 80 plants on which the insect feeds are listed.

When Asiatic garden beetles are in flight, they are attracted to electric lights, and they sometimes become so numerous in brightly lighted places that they annoy persons by flying about and alighting on them.

Though larvae are sometimes abundant enough in lawns to injure the turf, they are usually more abundant in weedy, overgrown land. Such land, which is common in the suburban areas where the insect occurs, furnishes perpetual breeding places that will produce a crop of beetles each year. In addition to injuring turf, the larvae have been known to destroy many ornamental and vegetable-garden plants.

In years of deficient rainfall so many eggs and larvae are killed that beetles are less abundant the following year. There has been no appreciable winter mortality of larvae from low temperatures in the last 2 years.

The Asiatic garden beetle is surprisingly free from the attack of native enemies. Two wasps that are parasitic on the insect in Japan and China have been introduced and liberated in this country, and one of these is now established in the Philadelphia area. In addition to native species that resemble the Asiatic garden beetle, there are three introduced forms that are sometimes confused with it.

Except in cases of extreme abundance, ornamental plants may be protected from attacks by the Asiatic garden beetle by spraying them with 6 pounds of acid lead arsenate and 4 pounds of wheat floor to 100 gallons of water.

Light traps may be used to catch the beetle. A small type using a 100-watt daylight bulb is suitable for home yards where there are no competing lights, and a large type equipped with a G–5 mercury-vapor bulb will catch many beetles even in brightly lighted places.

Turf in lawns can be protected against the ravages of larvae of the Asiatic garden beetle by treating it with acid lead arsenate at the rate of 10 pounds to 1,000 square feet. When heavily infested weedy land is plowed up and brought into cultivation for the first time, it is suggested that potatoes be planted the first year, as this, of all vegetable plants observed, appears to escape injury from larval feeding. Mulching with hay or straw during the active beetle season will prevent larval injury to strawberry plants.

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